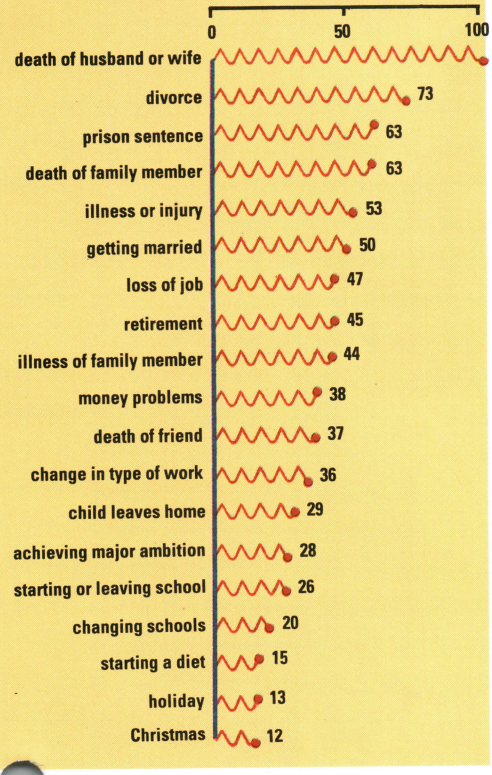
Death dogs every step *for soldiers engaged in jungle warfare. The stress was so great for men fighting in the Vietnam war, as shown in the film* Platoon, *that many suffered mental breakdowns.*

Orion/Kobal Collection



Stress affects people *in different ways. Figures above are averages. If several stressful events, happening together, total over 160 points, a person's health may suffer.*

Mark Franklin

STRESS
THE KILLER

- THE PAIN GATE
- CONTROLLING STRESS
- TRANQUILLIZERS

TOO MUCH STRESS CAN BE fatal. Stress-induced disorders have replaced infectious diseases as the major medical problem in industrialized countries. But stress is also a life-saver – one of the basic ingredients of the survival instinct.

You feel stress – fear or anxiety – when confronted with a situation outside your control. This can be a single event or a long-term problem. Stress factors, as they are called, vary from a man holding a gun to your head to having to work every day with someone you dislike. All change is stressful – even birthdays and Christmas!

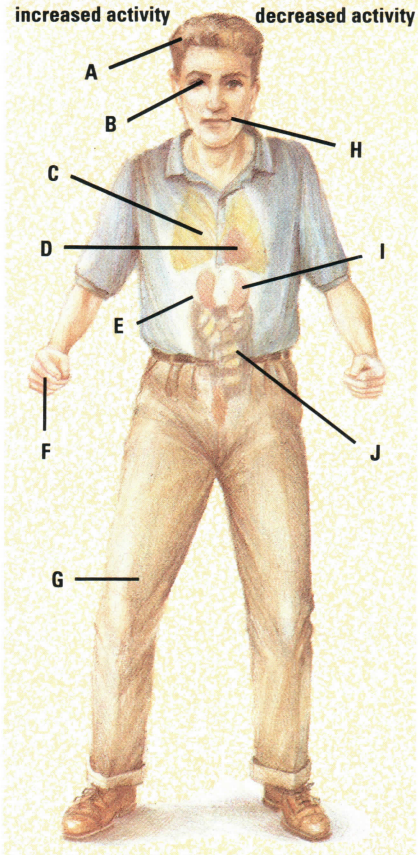
Faced with danger, the brain goes into red alert and prepares the body to run away or stand and fight. This is called the 'fright, fight or flight' response. Muscles tense, ready to move in an instant, the heart races and breathing quickens.

Under pressure

When the body is under extreme stress, chemicals called endorphins are released in the brain that suppress feelings of pain. This is the 'pain gate' phenomenon. For example, a fireman or soldier who is burned or injured, often does not realize the extent of his injuries until the danger has passed and his mind begins to calm down.

There is another side to stress – it can be good for you. An element of stress makes some kinds of work

FIGHT OR FLIGHT



Alison Catley

When the body is under stress, the hormones adrenalin and, to a lesser extent, cortisol, are released into the blood stream. Hormones control many of the body's activities, including its preparations for fright, fight or flight.

A *Hair* prickles upwards to increase the sense of touch

B *Eye pupils* dilate to give clearer sight

C *Breathing* speeds up to take in more oxygen

D The *heart* pumps faster so that more blood can reach the muscles

E The *liver* releases glucose to fuel the muscles

F *Skin* sweats to prevent the body overheating and turns pale because blood is diverted to the muscles

G *Muscles* tense and give off lactic acid, which heightens anxiety

H The *salivary glands* dry up

I Blood vessels in the *kidneys* constrict

J *Digestion* slows down.

enjoyable and prevents it becoming boring. Some people, such as stuntmen or racing drivers, seem to become 'addicted' to the sudden surge of adrenalin extreme stress can bring. Only when taking a bend at 180 km an hour do they feel truly 'alive'.

Red alert

This 'fright, fight or flight' response is triggered every time you come up against a situation that makes you anxious or worried. The whole body is ready for action. But physical action is not usually required to deal with a long-running stressful situation. So the body remains tense and stressed.

Blood vessels stay constricted and high blood pressure becomes permanent. Ulcers may develop because the digestive system is not working properly. Neither is the immune system, so that colds, 'flu and all kinds of infections are caught more easily. Sufferers complain of feeling 'on edge' and 'wound up' all the time. The body cannot keep this up forever. Exhaustion sets in and eventually there is usually some kind of mental or physical breakdown or both, as the two are closely linked.

Breakdown

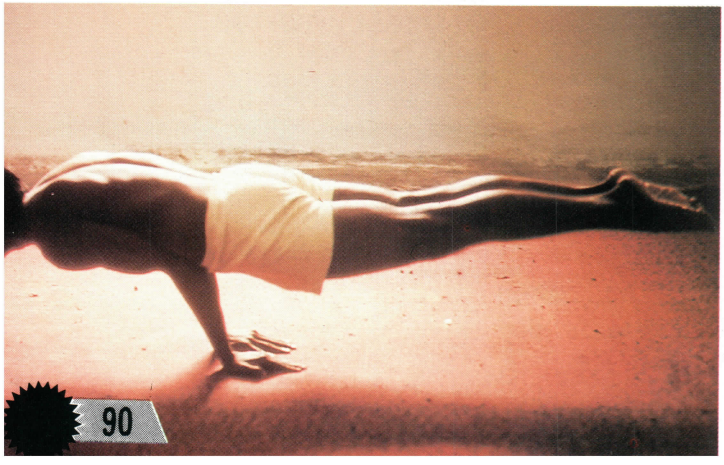
The sufferer becomes confused, angry and depressed, spiralling down to the point when he or she cannot cope, for the moment, with every day living. Under these circumstances, middle-aged people are particularly vulnerable to heart attack or stroke – together, the number one killers in industrialized countries.

Anxiety can be treated with drugs called tranquillizers. Librium, Valium and Mogadon are taken by millions of stress-sufferers. They calm the mind (some find they depress rather than sooth), relax muscles and control insomnia. However, tranquilliz-er-users find that the effectiveness is often short lived. There is also a danger that users might become addicted. When they stop taking the pills, they may get withdrawal symptoms, such as panic attacks and insomnia, which are worse than the original stress.

International Stock Exchange Photo Library

Gamma/Frank Spooner Pictures

***Death-defying** feats of a trapeze act and the monotony of working on an assembly line putting together microwaves have one thing in common – they are both stressful activities.*



Rex Features

***Yoga** is an effective antidote to stress. Hatha yoga is a series of physical exercises designed to benefit most of the muscles, organs and glands, and make both mind and body feel alert and relaxed.*

Just amazing!

DEATH WISH

IN 1939, THE HARE POPULATION OF THE AMERICAN STATE OF MINNESOTA PLUMMETED. STRESS CAUSED BY OVERCROWDING TRIGGERED 'SHOCK DISEASE' – A FATAL OVER-PRODUCTION OF THE ENDOCRINE GLANDS.

Paul Raymonde

HEAT TREATMENT NATURAL FLAVOURS TINNED SALADS

FOOD INDUSTRY

Spectrum Colour Library

ZEFA

***The food industry** is becoming increasingly automated. A large bottling plant (above) can fill and seal 180,000 litre bottles of soft drink per hour.*

EVERY WEEK, NEW FOODS find their way on to supermarket shelves, enticing us to try something different. This revolution in choice is partly due to innovations within the food processing industry, and partly to public demand for nutritious, time-saving meals.

Top manufacturers take great care to ensure that foods are safe for human consumption when they go on sale. The production of a new pâté product, for example, which by its nature is susceptible to contamination by micro-organisms, will be strictly controlled.

Chicken livers are first hand-washed under high intensity lights by staff wearing clean hats, boots and overalls, who have sterilized their hands in alcohol solution. These staff are tested to make sure they are not colour-blind so that they can detect any discolouration in the livers, along with the presence of stones or feathers.

The washed livers are processed into a fine emulsion in stainless steel bowls by the action of rotary blades. Other ingredients such as bacon, sherry or other flavouring agents are added at this stage.

The flavoured mixture is injected into plastic pots that are loaded on to trays for cooking at a tempera-

ture of 82°C for 10 minutes.

This kills salmonella and listeria bacteria, among others, which cannot survive above 72°C. The pots are manually checked during cooking with a needle probe digital thermometer to make sure the pâté is cooked right through.

The cooked pâté is packaged, then cooled rapidly in liquid nitrogen to a temperature below which bacteria cannot grow. Small quantities of the product are checked in the laboratory for the presence of bacteria, and any contaminated batches are withdrawn.

Daudier/Jerrican

The cold chain

A 'cold chain' ensures that the pâte´ reaches the customer in top condition – ie from the factory kitchen to refrigerated transport vans to refrigerated displays in shops and supermarkets the pâté is continually kept at a temperature below 5°C.

Temperature also plays a crucial part in the manufacture of stirred yogurt (yogurt which pours). First the level of solids in milk – the basic ingredient – is raised by evaporation, or by adding skimmed or concentrated milk. This is then homogenized – forced through tiny holes under pressure to break up the fat globules to a uniform size. This increases the viscosity (resistance to flow or stickiness) of the final product and gives it a smooth texture and creamy flavour.

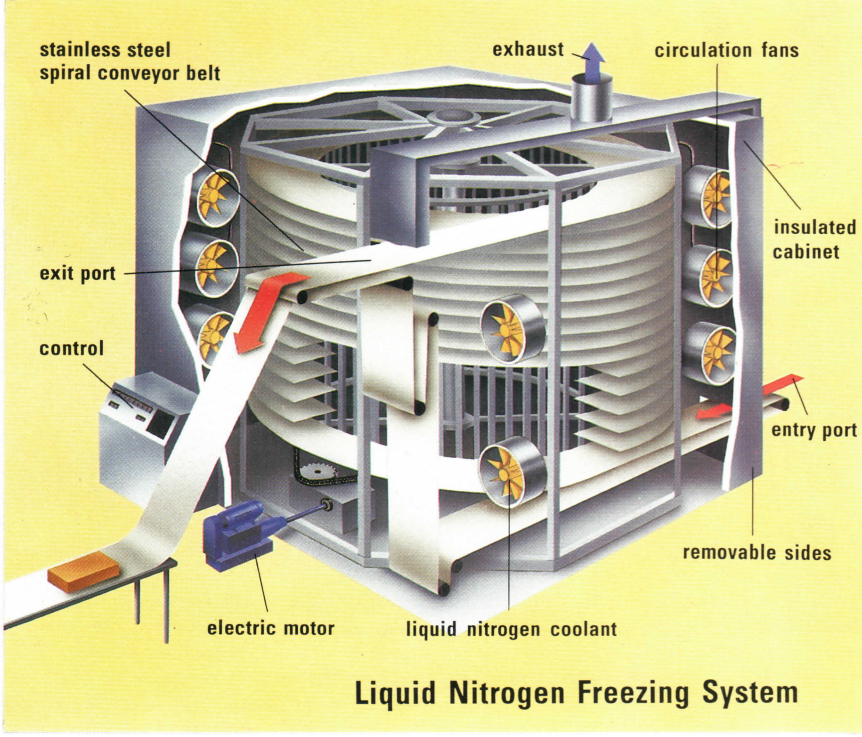
Quality control *checks, for colour blemishes, are carried out before the potato crisps are automatically weighed and bagged.*

Tony Stone Photo Library, London

ZEFA

Sausage meat *is squeezed out in a continuous 'rope' from an automated machine before being portioned into individual links. Protective clothing to ensure good hygiene (far left) is essential in any factory producing food for human consumption.*

Freezing food *very fast to –196°C using liquid nitrogen coolant helps it retain its original shape and texture when thawed.*



Matthew White

Liquid Nitrogen Freezing System

Pasteurization

The mixture is pasteurized at 85–95°C for 15–30 minutes to kill bacteria, then cooled to 40–45°C.

A culture of harmless bacteria called a 'starter' is added to the milk. The culture ferments the milk sugar (lactose) and turns the milk into yogurt. This process takes three to six hours. The culture, while growing, also produces an acid which gives yogurt its characteristic flavour.

Flavourings

Yogurt thickens during incubation as the milk proteins coagulate (set). After incubation the yogurt is

cooled to, and remains at, 5°C to stop further bacterial growth. Pieces of fruit and various artificial or natural flavourings may be added at this last stage.

Blue cheese is another product to which starters are added during processing. Fungal cultures, sprinkled on to the cheese during an early stage of processing, produce the distinctive blue veins.

Factory cheeses

Traditionally a handmade craft, cheesemaking has adapted well to mechanization. French Roquefort, for instance, a blue cheese, can be produced and stored in the factory and still taste like its traditional counterpart which was matured in caves.

Milk coating

Scientists are currently investigating different ways of keeping food fresh in its natural state – without, for instance, freezing or drying it. With peeled or cut fruit or vegetables, one method is to coat the food with an edible film of milk or cereal proteins and ascorbic acid (vitamin C).

When applied to the cut side of an apple, for instance, the coating prevents oxygen in the air combining with the fruit enzymes and turning them brown. By keeping moisture in and air out, the coating keeps fruit fresh for up to three days.

In future we may also be able to buy fresh salads in tins. A food chemist in New York had discovered an enzyme existing in most plant tissues that can reverse the softening effect that cooking has on vegetables. While cooking plays an important role in ridding vegetables of bacteria before canning, these enzymes could help to keep them crisp and firm.

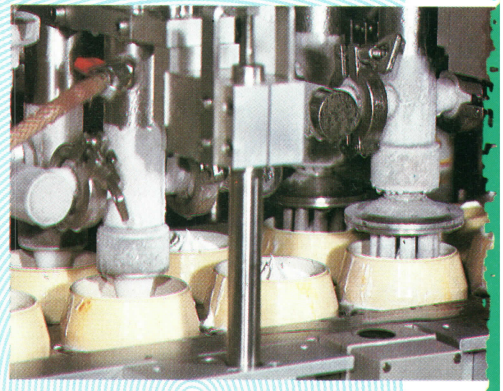
Cadbury Ltd

***Sweets** pass through an enrober – under a curtain of chocolate liquid. Excess icing falls through the wire belt and is recycled.*

Boiling sugar

Sweets purchased from the local corner shop begin life as just a few ingredients at the start of a mass production process. Hard boiled sweets such as fruit drops, clear mints, butterscotch and barley sugar, start out as boiled solutions of sugars. Heated in steam pressure

TASTY EXTRACTS



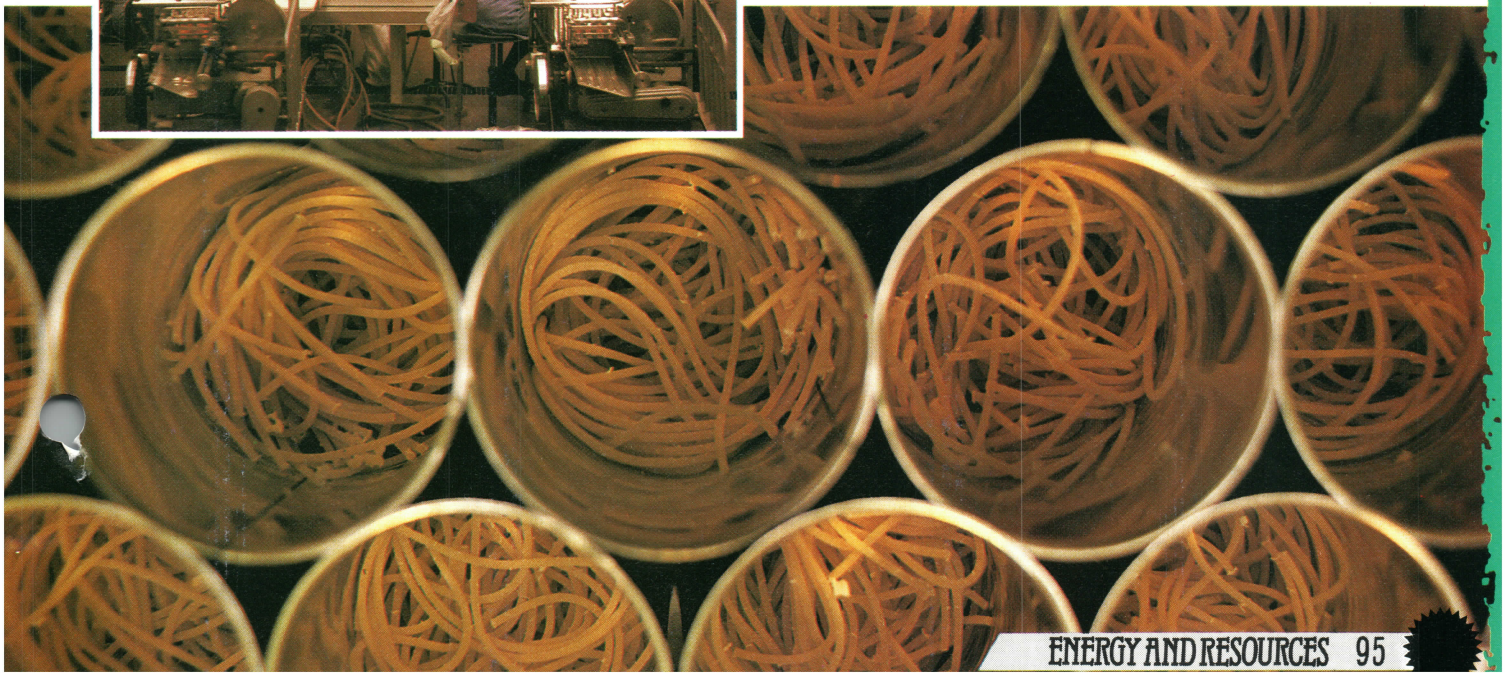
Alfred & Co Ltd/Technogel

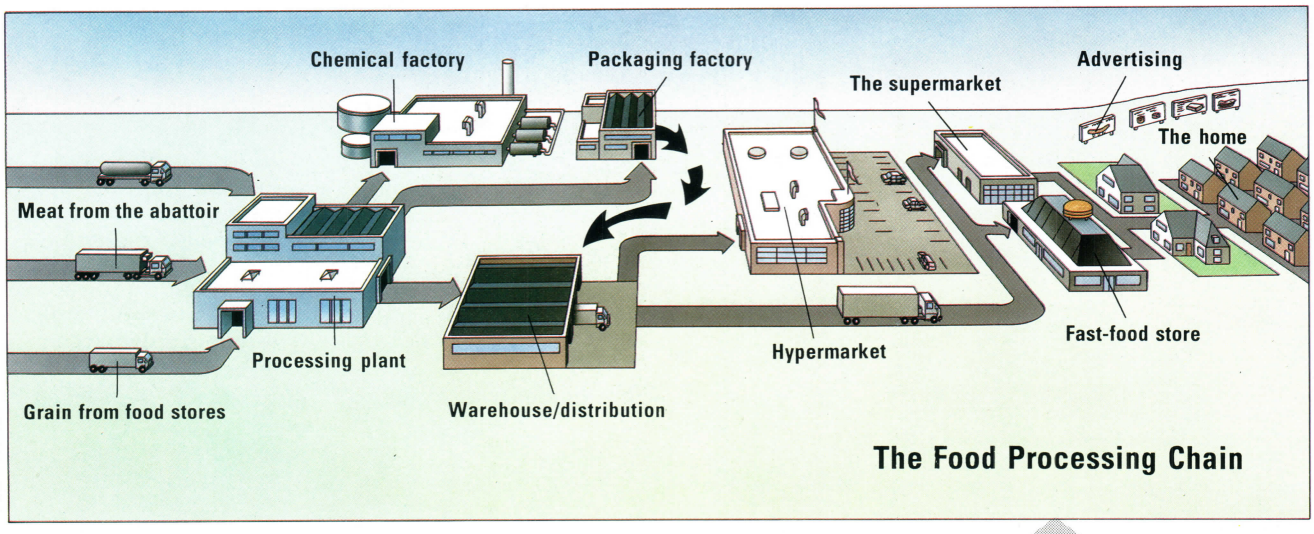
Today many countries are restricting the use of harmful food and drink additives. Cola drinks will fade to light brown as the caramel used to colour them is cut back by legislation. Red cheeses will become pale as titanium dioxide is restricted. Similarly, ice cream (above) will be much more pale.

Natural flavourings, aromas and colourings are difficult to extract from plants, fruits and vegetables and are vulnerable to climate and disease. But scientists have isolated the cells which produce these effects and have grown them in the laboratory. This means that in future, natural flavourings will be produced all year round and will replace artificial flavours used in, for instance, ice cream.

HJ Heinz Company Ltd

***Many food factories** still rely heavily on human labour. Canning (below) is one area that has been almost fully automated. Cans can now be filled and sealed at a rate of 2,000 per minute.*





Paul Desmond

The Food Processing Chain

cookers, the sugar solutions are prevented from crystallizing (becoming solid) on cooling by the addition of corn syrup.

Mechanical kneading

When the mix is allowed to cool it is mechanically kneaded with flavourings and colourants, although in continuous production these ingredients may be added to the hot liquid syrup. The gooey mass is then shaped by being passed through rollers with impressions on them to create the eventual shape of the sweet. The final satin-like finish is achieved by repeatedly pulling and stretching the sticky mass using mechanical rotating arms.

Chocolate

Chocolate confectionery falls mainly into two categories. Bars of solid chocolate are produced by pouring liquid chocolate into moulds, often fruit or nuts are added before the chocolate cools and sets.

Chocolate-covered products are made either by pouring the filling into a moulded chocolate shell, and then finishing this off with a layer of base chocolate, or by a process known as enrobing.

A machine called an enrober, using a system of pumps and troughs, produces a curtain of chocolate through which the fillings are transported on a wire-mesh conveyor belt. Excess chocolate drains off through the mesh and is recycled. The coating is set by passing the chocolates through a cool air tunnel before packaging.

***Food processing factories**, with the help of the chemical and packaging industries, turn raw foods into the varied products available on supermarket shelves. Chemicals are added to preserve, colour and flavour food. Packaging can preserve, ripen, heat and advertise a product as well as contain it.*

Labat/Jerrican

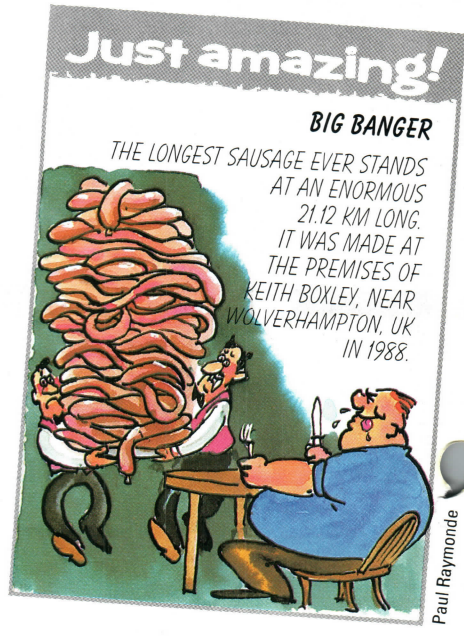
***Professional tasters** test a new product under artificially coloured lighting to ensure that the appearance of the food does not influence their judgement of its taste and texture.*

FRESH FROM THE LAB

ZEFA

Carrots are processed by food factories throughout the year, but one of the problems in the past has been their loss of sweetness and deterioration if overwintered in the field. Carrots kept in conventional storage facilities – immersed in a refrigerated liquid such as brine (very salty water) at 2°C – show root growth and become soft after four to five months.

However, new storage techniques are being developed by British scientists. In trials, where carrots have been kept at 5 °C, on banks of ice, at high humidity (moisture), they have shown negligible root growth and remained firm and crisp even after nine months storage. The new storage technique could help bridge the spring gap before the new season's crop.



Paul Raymonde

RECYCLING

***A landfill site**, where some rubbish will decompose. Plastics, metals and glass, however, remain intact for decades. Using recycled glass (below), reduces waste and saves energy.*

United Glass Ltd

- WASTE POWER
- BIOPLASTIC
- CAR SHREDDERS

Pascal Nieto/Jerrican

WE HUMAN BEINGS PRODUCE enormous quantities of waste – needlessly discarding all kinds of potentially valuable material, from newsprint to old motor cars. However, at last many industries are slowly waking up to the value of recycling used materials.

Manufactured goods cost the consumer more than just money. It has become startlingly apparent in recent years that:

- the earth's natural resources of oil, gas and coal are being depleted
- the destruction of trees in the rain forests threatens wildlife and contributes to the 'greenhouse effect'
- the environment is dangerously polluted by waste products

About 35 million cars are made each year – and each year millions of them end up on the scrap heap. A huge amount of scrap metal can be recovered from cars and many of the parts can be salvaged for use in the same state. When cars have been stripped of useful parts, they can be fed into a steel furnace and the resultant steel sold off. A process developed in Belgium can be used to separate steel from the other materials in scrapped cars.

Reusing lead

Cold liquid nitrogen at nearly –200°C is sprayed on to the car body before it reaches the shredder. At this temperature the steel becomes brittle and breaks up into small fragments, leaving the other metals such as copper and aluminium as much larger pieces. The steel can then be easily melted down and reused.

Vehicles are also useful in providing lead – this is found in car batteries. Battery plates are smelted to produce lead for new batteries.

Rubber from the thousands of tyres worn out on the roads can be recycled to produce valuable chemicals. This involves heating the tyres and reclaiming a liquid oil that can be used in the manufacture of other chemicals, a gas which can be used as a fuel, and a carbon-based residue useful for building roads.

X-ray film

Silver, one of the more valuable metals, is used in the X-ray film and photographic paper industries. It evaporates during the production of the film and paper. The gas is cooled by water sprays, then passed into an electrostatic precipitator that attracts the silver particles. The result is an almost total recovery of the silver. It is then recycled into the photographic paper production.

***Aluminium** is one of the most expensive metals to produce. The energy required to make a single drinks can is equivalent to half a can filled with oil. But recycling an old can requires only five per cent of the energy required to make a new one.*

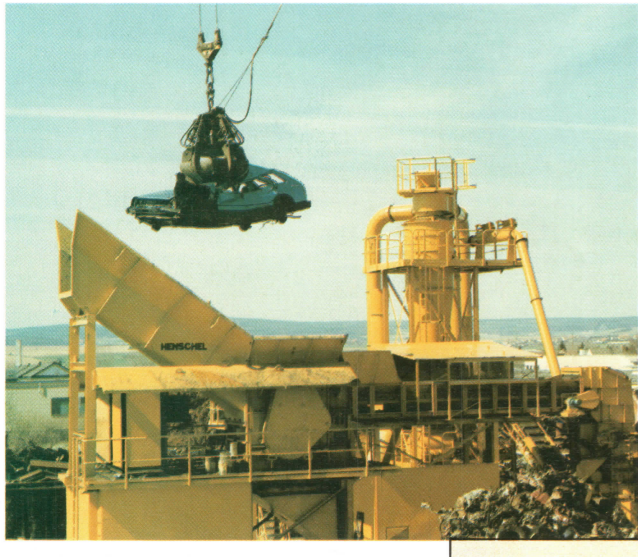
Spectrum Colour Library

also be used as an alternative to sand in building materials.

In the United States, where there are compulsory bottle deposit laws, plastic bottles are recycled. The bottles pass through an eight-stage

BIOLOGICAL PLASTIC

Unlike most rubbish, man-made plastics are very durable and do not decompose in the presence of bacteria. However, American scientists at the University of Massachusetts and Amherst have produced a biodegradable plastic from a strain of bacteria. Bacterium from the Pseudomonas strain is grown in an atmosphere without nitrogen. The bacterium will make up to 80 per cent of its bodyweight out of natural plastic. The plastic is extracted in fermentation vessels and dried to form granules. These can then be manufactured into biodegradable plastic packaging.



Thyssen Henschel

***A shredder** will accommodate an entire car. The Lindemann shredder (below right) compresses scrap before shearing it with 'hammers'. The pieces are hurled around the chamber until they become small fragments. They are then fed on to a conveyor belt.*

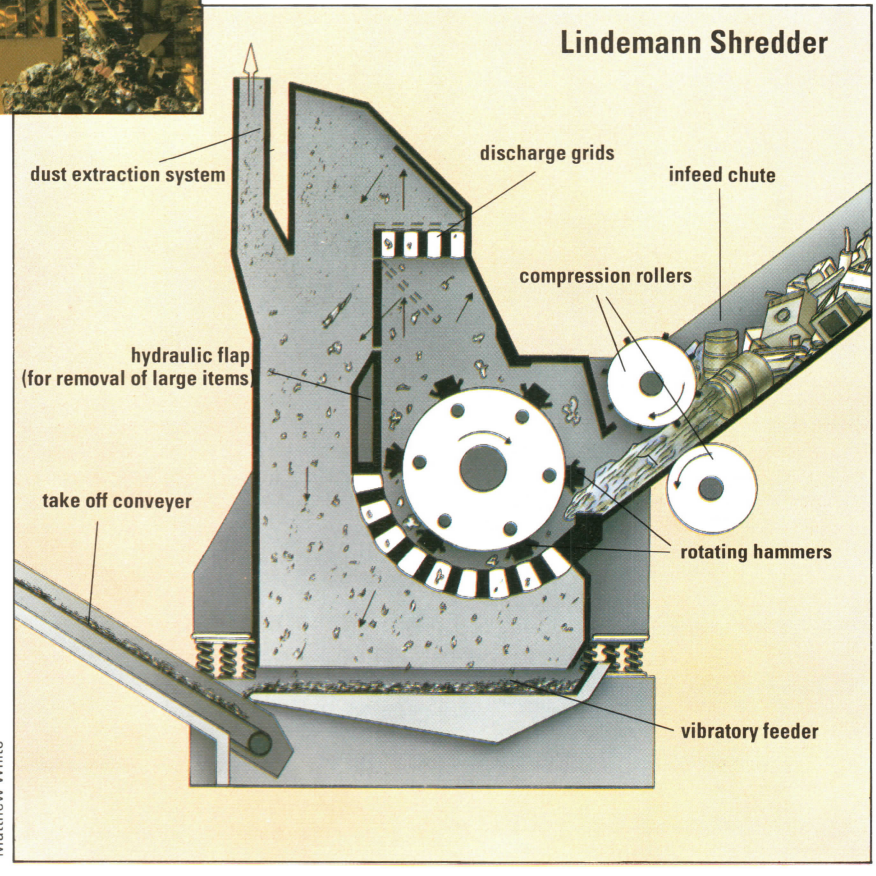
Many glass containers such as milk or soft drink bottles, can be reused without being remelted provided they are returned to the manufacturer undamaged. Glass makes up about ten per cent of household rubbish.

Bottle banks – places where people can deposit their waste bottles – have proved a useful source of glass. However, in Britain only eight per cent of glass is recycled, perhaps because there is only one bottle bank per 22,000 people. In Holland where considerably more glass is recycled, there is one bottle bank per 1400 people.

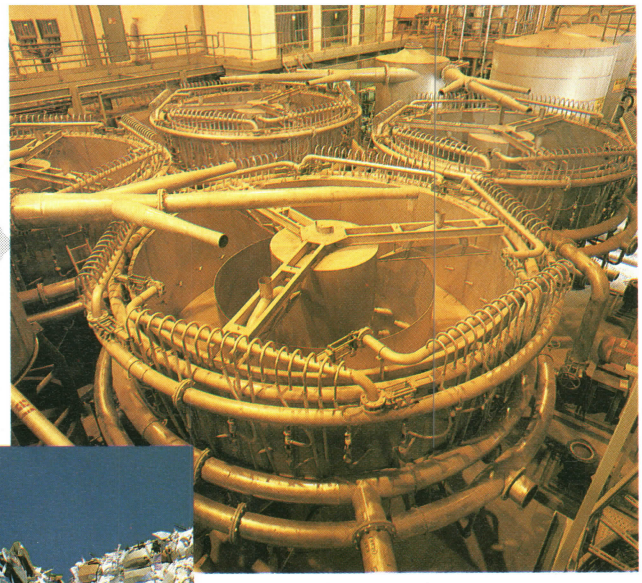
Soil conditioner

The recycling process is simple – old broken glass is added to new molten glass in a furnace. The result is high quality glass produced with a considerable saving in energy.

Alternatively, molten waste glass can be cooled in water to form a fine glass called frit. This is used as a soil conditioner or together with asphalt to surface roads. Frit can



Matthew White



Bridgewater Paper Co

***A de-inking vat** where air and soap are added to the paper 'porridge'. Ink particles cling to the foam and rise to the surface where they are vacuumed up. Paper of all colours is easy to recycle (below), but only a quarter of waste paper is reused.*

Spectrum Colour Library

process of sorting and cleaning. Initially they are sorted by colour – the clearer this is, the higher the value of the plastic.

Water bath

The sorted bottles are ground up, washed with water and solvents to extract dirt and glue, then split into PET (polyethylene terephthalate, which comprises around 70 per cent of the plastic) and PVC (polyvinyl chloride). This is done by pouring the ground plastic into a bath filled with water in which the PET sinks and the PVC floats.

The PET and PVC is separated, dried and put through a metal extractor that pulls out any metal neck rings. What is left is moulded into tiny flakes of resin and baked for six hours at 180 °C. This re-crystallizes the plastic, which can then be sold as raw material for pipes, bottles (non-food type) and thermal fillings for clothes.

Recycling paper has become a major concern today, if 75 per cent of waste paper and cardboard was used to make new paper, about 35 million trees could be saved each year. In the past, recycled paper was often a greyish, rough-textured material. New techniques have recently emerged, however, to produce high quality recycled paper.

The used paper is de-inked, then put into a chemical bath to separate the fibres. Water is blended with the mixture to produce a kind of porridge, which is passed through a sieve to remove any staples. The fibres are then pulverised in a refiner. This 'stock' is poured on to a moving plastic mesh which, along with a vacuuming process, drains off the water, leaving behind a layer of fibre that is compressed by rollers. The resultant fibrous web is further dried by steam-heating.

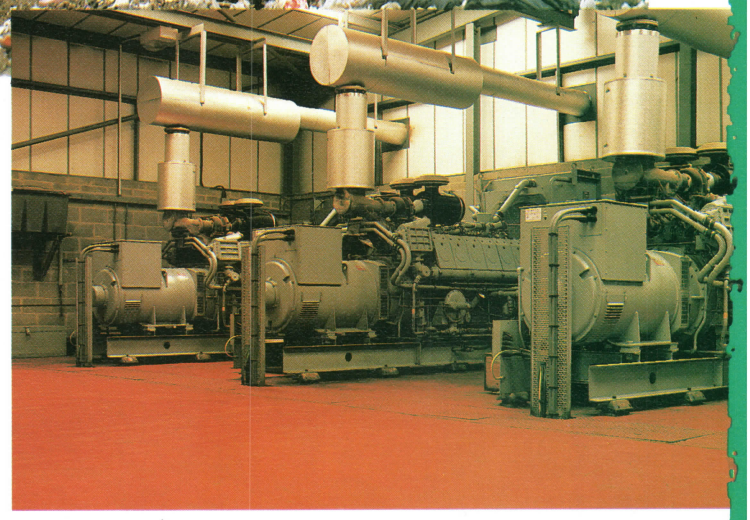
Computer control

The modern paper-making process differs significantly from traditional techniques in the use of X-rays infra-red sensors and computer control. All of these are used to monitor the quality of paper in terms of its thickness, weight, water and mineral (chalk or china clay) content.

An electronic eye controls the colour of the paper, highlighting any change that is beyond the sensitivity of the human eye on a computer screen graph. The final product has a six per cent water content and is up to 20 per cent cheaper to produce than paper made from wood pulp.

Used aluminium cans are one of the few waste products from which all of the scrap material can be reprocessed to make new cans identical to the old ones. In the USA

Shanks & McEwan (Southern) Ltd



***Rubbish** may provide the energy of the future. Refuse, covered with a mixture of artificial and real soil, releases highly combustible methane gas. In Bedfordshire, England, electricity generators (right) are fuelled by landfill methane gas.*

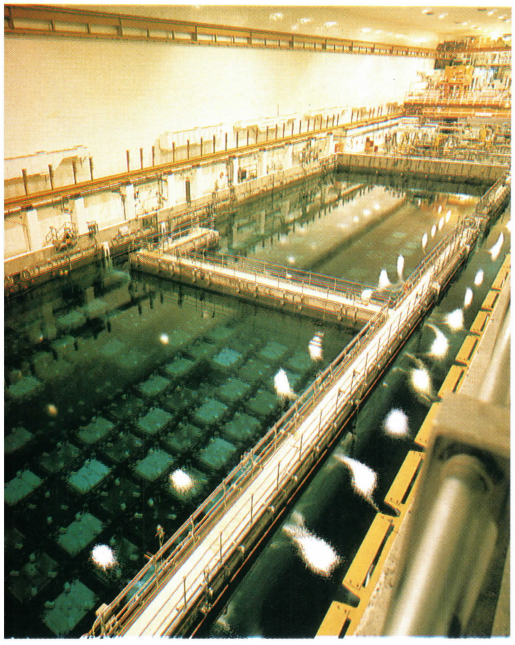
Shanks & McEwan (Southern) Ltd

Just amazing!

WHAT A DUMP!

AT GEORGSWERDER, JUST OUTSIDE HAMBURG IN WEST GERMANY, MORE THAN 150 MILLION CUBIC METRES OF INDUSTRIAL WASTE HAVE BEEN DUMPED SINCE 1948 – CREATING A MOUNTAIN OF RUBBISH MORE THAN 40 METRES HIGH THAT COVERS AS MUCH GROUND AS A LARGE VILLAGE.

Paul Raymonde



Mere Words/SPL

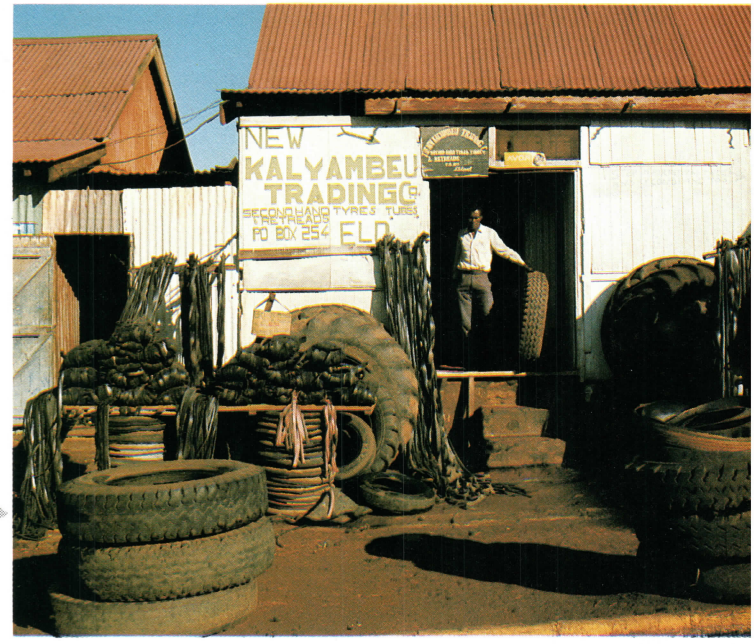
***Spent nuclear** fuel is stored in cooling ponds before being separated into its constituent parts – 96 per cent is uranium that, after recovery, will be manufactured into new fuel.*

the recycling rate is over 50 per cent, but the rest of the world is lagging behind. In Britain people buy more than 6 billion aluminium drinks cans every year. Of these, only a quarter are recycled.

Aluminium recycling is highly cost-effective. It saves up to 95 per cent of the energy needed to produce the metal from raw materials. The cans are melted down to produce ingots (piles of unwrought metal), which are then rolled into sheets ready to be moulded into new cans.

Waste from the coal-burning industries, in the form of fly ash, can be used in the manufacture of cement and concrete building products. The ash is recovered from the flue gases of chimneys burning bituminous coal.

Some waste can be recycled to provide a source of energy. Animal waste contains energy that can be extracted in anaerobic digesters – large vats in which bacteria break down the slurry anaerobically (without the presence of air). This process produces methane gas, which can be tapped as a fuel.



***Recycling** materials does not always involve hi-tech reprocessing techniques – in Kenya old rubber tyres are cut into strips to make a cheap alternative to bed slats.*

Margaret Murray/Hutchison Library

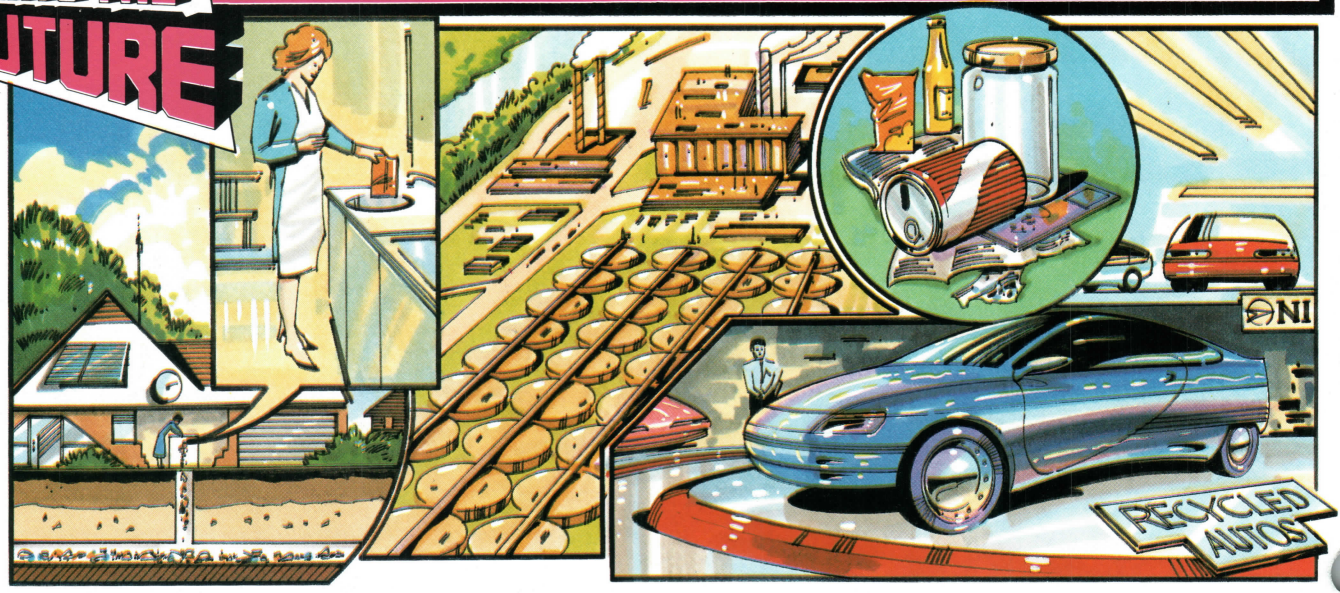
In China, huge digesters are built underground. In 1981 China reported to the United Nations that there were over seven million biogas digesters in the country, mostly in the Szechwan Province, which provided a supply of methane gas to around 30 million people and 150 methane-fired power stations.

PROFILE RUBBISH

	Annual domestic waste (tonnes)	Equivalent per person (kg)
USA	200,000,000	875
Canada	12,600,000	525
Australia	10,000,000	680
Japan	40,225,000	344
W Germany	20,780,000	337
France	15,500,000	288
G Britain	15,816,000	282
Italy	14,041,000	246
Spain	8,028,000	214
Holland	5,400,000	381
Switzerland	2,146,000	336
Norway	1,700,000	415
Sweden	2,500,000	300
Denmark	2,046,000	399

INTO THE FUTURE

WASTE DISPOSAL WITH NO WASTE



Joe Lawrence

▲ *Future homes will be equipped with 'refuse centres' linked to a 'refuse mains' system, which will whisk away all household refuse to out-of-town plants.*

▲ *Here, programmed automatic sorting machines will separate all reusable material from unusable refuse – this will be used to fuel generators.*

▲ *All reusable materials will be automatically sent to a reprocessing plant that will be able to create new raw materials for manufacturers.*

HYPOTHERMIA DEHYDRATION INSULATION

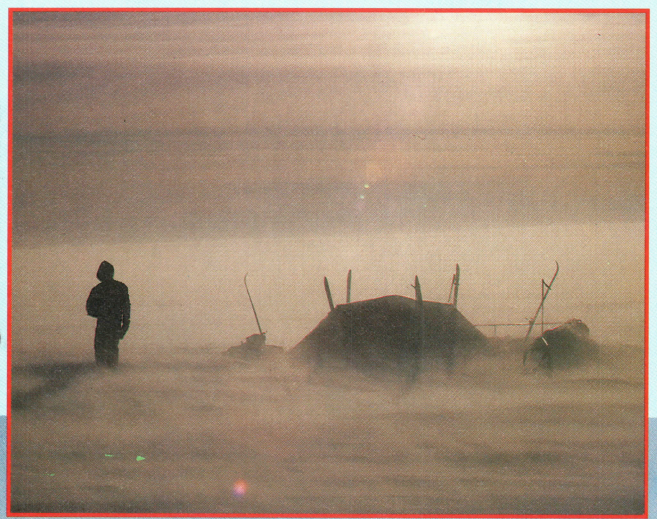
BRAVING THE ELEMENTS

UNPREPARED, IN THE WILD, Man is as defenceless as any other creature. Extremes of heat, cold and altitude are among the most dangerous hazards to be faced.

A person can survive for several weeks without food, especially if they are inactive. But if body salt is lost through sweating it must be quickly replaced. Salt tablets are the easiest way to carry salt and can be quickly dissolved in water.

Without water, survival under the daytime desert sun is measured in hours. Even resting in the shade an adult must take in at least 1 litre of water a day to prevent dehydration. At 35°C, the basic requirement soars to 5 litres – much more if moving or working strenuously.

Exposure to low temperatures poses different problems. To function properly, vital organs, such as the heart and kidneys, have to be kept at a constant temperature of about 37°C. If the body's 'core temperature' dips much below this, hypothermia sets in. The person shivers and breathes more slowly and heart rate is reduced in an effort to save energy. Hypothermia is dangerous to human life; however a similar process – hibernation – allows some animals to survive winter. Their metabolic rate slows and they are torpid for lengthy periods.



Jim [illegible]ner/Chameleon Television Ltd

***The survival basics** – food, water, warmth and shelter – change in order of importance depending on where you are. Water and shelter from the sun are of chief importance in the desert, while warmth and shelter take top priority in polar regions. This ski party (below) sit out a spring storm. The nose plaster is a guard against frostbite.*

Protective clothing

In extreme cold, the right type of clothing is essential. Clothes should be worn in layers to trap air warmed by the body and the outer layer must be thickly insulated and waterproof. Eider or goose down remains the most effective insulating

John Cleare/Mountain Camera

FROSTBITE – INJURY CAUSED BY EXTREME COLD

When skin becomes very cold, especially at the extremities of the body such as the hands and feet, the blood vessels inside it shrink and cut off the flow of blood. Gradually the affected area turns numb and changes from red to white to yellowish-grey. Because of the loss of feeling, the victim may not realise he is suffering from frostbite. Medical help must be sought for this condition. In mild cases, immersion in water of about 40°C is sufficient to restore circulation. But in severe cases, body tissues may be damaged beyond repair and may have to be amputated to prevent infection spreading.

Colin Monteath/Mountain Camera

material, but is bulky. Where less bulk is required, man-made alternatives are available.

A synthetic fabric called *Gore-Tex*, for instance, has over a billion tiny openings per square centimetre. These 'pores' are so small that they keep out wind and rain while allowing water vapour from the body to pass through. This protects the wearer from bad weather on the outside, but stops condensation from building up inside the clothing.

Space blanket

Another man-made survival aid, the Space Blanket, is a very thin layer of aluminium bonded to a lightweight plastic sheet. The aluminium reflects body heat back on to the wearer while the plastic serves as an effective insulator. The only problem is that, not being porous, the Space Blanket tends to trap sweat as well as heat.

In addition to the cold, a shortage of oxygen poses problems at high altitudes. The body can be trained to adapt to a lack of oxygen for short periods – it increases the number of red blood cells that carry oxygen around the body. Climbers who do not train their bodies slowly and properly for high altitudes risk death from lung oedema – where tissue fluid is forced into the lungs.

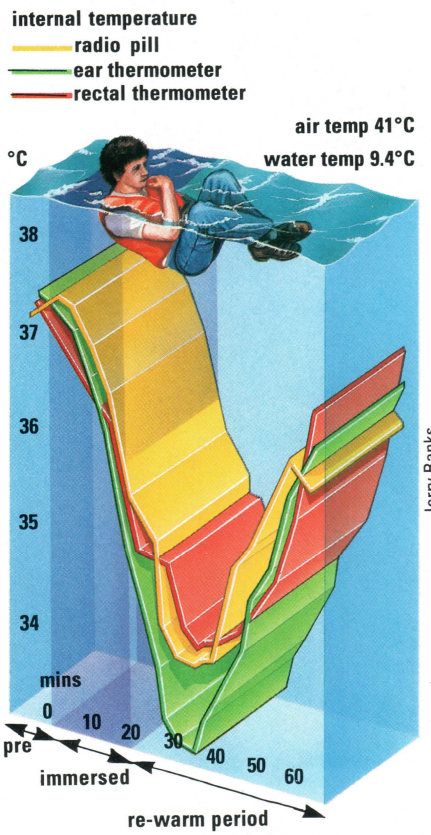
High altitudes

The highest point at which humans make permanent homes is 4,875 metres – in the Andes mountains in Bolivia. The local Indians who live higher than this claim to have to descend in order to conceive and have children.

***Foods** for an expedition into inhospitable regions must be nutritious and, like other equipment, easy to transport. Fats are high in calories and are hardest to find if the explorers are forced to live off the land so butter, lard or oil is important. Dehydrated meat blocks and chocolate are high energy foods. Salt is essential.*

Roger Mear/Remote Source

Body Heat Loss In Cold Water



Jerry Banks

***Recordings** from a swallowed radio pill, and from ear and rectal thermometers, show that the body takes time to regenerate heat after being immersed in cold water. After-drop (continued fall of body temperature after removal from cold water) can kill. HELP (The Heat Escape Lessening Posture, top) protects areas of high heat loss: the sides of the chest and the groin.*

Staying alive in cold seas and rivers poses one of the greatest of all challenges. In water of 0°C a person may survive for only 1 hour. A fat person will last longer than a thin one, having a greater resistance to the cold.

In water warmer than 20°C, swimming will increase the blood supply and keep the body warm.

Reserving heat

Swimming in water below 20°C is one of the quickest ways of losing body heat. Cold water flowing past moving limbs washes away the warmth created by increased blood flow. To try to keep warm, a person must stay as still as possible and draw in his or her arms and legs.

In shark-infested water, sharks will be attracted by traces of blood or by weak, splashing movements. If threatened, a person should attempt to swim using strong, regular strokes, often changing direction suddenly since sharks cannot easily veer from side to side. As a last resort, a smart jab on the top of the snout may repel an attack.

Just amazing!

FLASH HAIRCUT

PARK RANGER ROY SULLIVAN WAS STRUCK BY LIGHTNING SEVEN TIMES IN 41 YEARS. HE SURVIVED EVERY TIME – BUT TWICE HAD HIS HAIR SINGED OFF.

Paul Raymonde

SAILPLANES THERMALS HANG-GLIDERS

RIDING ON AIR

GLIDERS AND VULTURES have one important thing in common. They both rely on rising air currents to stay aloft.

Both birds and planes have wings shaped to provide lift as they move through the air. But that lift alone is not enough to overcome the weight of the glider (bird or plane). A bird flapping its wings or an engine-powered plane can generate enough additional lift to stay airborne by driving itself forward at higher speed. But a glider must gradually fall back to earth unless it can find an updraft of air. The trick is to know when and where such updrafts occur.

Bubbles of warm air

When the sun shines on land, more of its heat is absorbed by some parts of the ground than others. For example, exposed rock or ploughed fields will get hotter more quickly than a grassy or wooded area. The air above a warmer patch of land, in turn, becomes heated more rapidly than the surrounding air, so that it rises. Such a warm, upward moving bubble of air, called a thermal, is ideal for gliding.

Each September, many thousands of birds on their winter migration

The parafoil *was invented by American Domina Jalbert. Made entirely from nylon, it gains its shape from the action of the wind entering openings on the wing's leading edge.*

Tony Stone Photo Library, London

from Europe to Africa gather on the island of Gibraltar in the Mediterranean. The reason is that Gibraltar, being basically a naked lump of rock surrounded by sea, produces exceptional thermals. These allow the birds to soar effortlessly during the early part of the day and then to glide slowly down over the straits to the African continent.

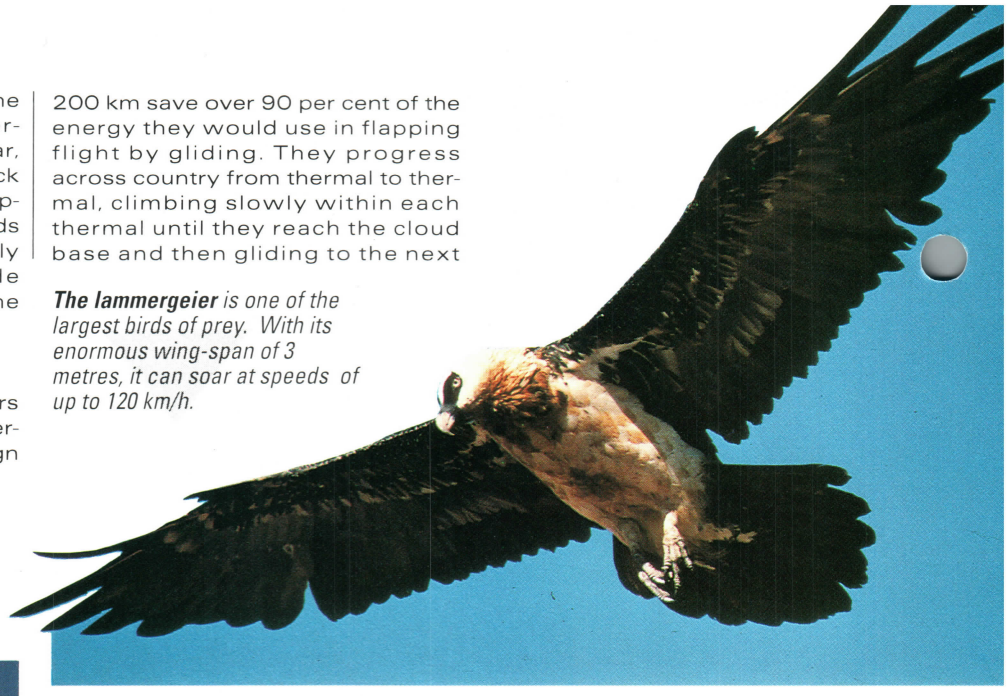
Thermal soaring

The pilots of gliders and hang-gliders learn to recognize places where thermals are likely to occur. One sure sign is the presence of birds, such as gulls, wheeling around and around without flapping their wings.

The steep windward side of mountains and hills is another place where there are often strong updrafts as oncoming air is forced up and over the 'obstacle'. Eagles and cliff-dwelling seabirds as well as hang-glider pilots use these deflected air currents to gain altitude and prolong their periods of flight.

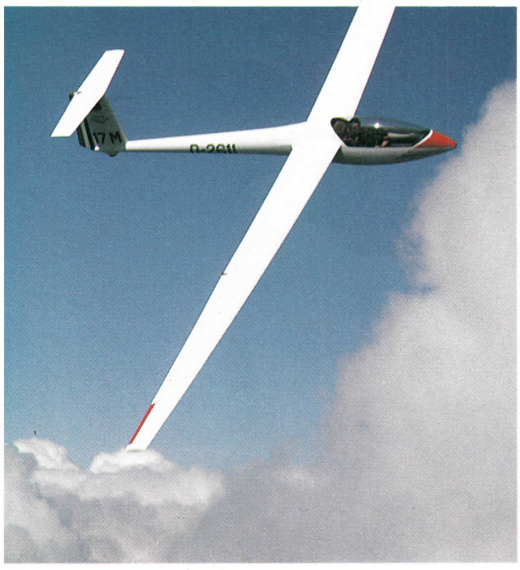
Vultures on a daily round trip of 200 km save over 90 per cent of the energy they would use in flapping flight by gliding. They progress across country from thermal to thermal, climbing slowly within each thermal until they reach the cloud base and then gliding to the next thermal in their line of flight.

The lammergeier *is one of the largest birds of prey. With its enormous wing-span of 3 metres, it can soar at speeds of up to 120 km/h.*



Nigel Dennis/NHPA

A glider's wings *are as slender as possible to reduce wind resistance (or 'drag').*



Peter F Selinger

A bird such as the albatross has long, slender wings that are highly efficient for gliding, since they provide good lift. The same type of wings are used on modern gliders. Materials such as plywood or fibreglass enable weight to be kept to a minimum, while a narrow fuselage allows the glider to cut easily through the air.

As a glider or sailplane has no engine, it naturally needs assistance when taking off. It can be launched from a hilltop by a special catapult.

Taking off

Normally, however, gliders are towed into the air behind a small plane. At an altitude of around 1,000 metres the tow cable is released and the glider flies free. Another method is winch launching: the glider is launched into the air in a similar manner to a kite. One end of long steel cable is wound on to a powered drum and the other end attached to the glider. Once the cable is vertical, the pilot either lets it go or it is automatically released.

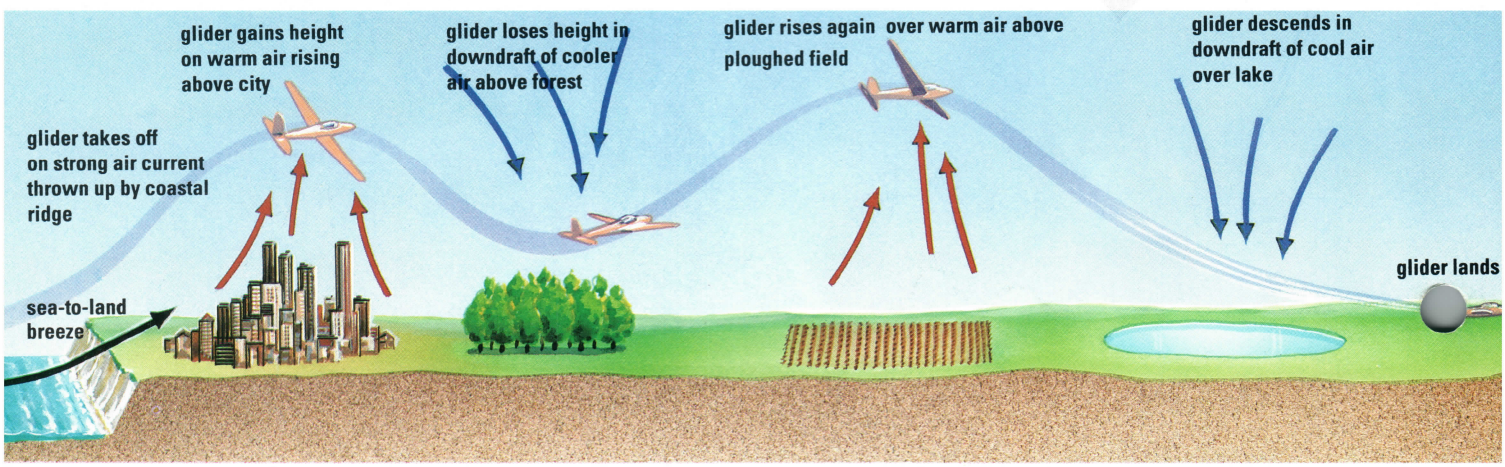
After launching, the glider will slowly begin to drift downwards so the pilot looks for a thermal or air current where the rising air will carry the

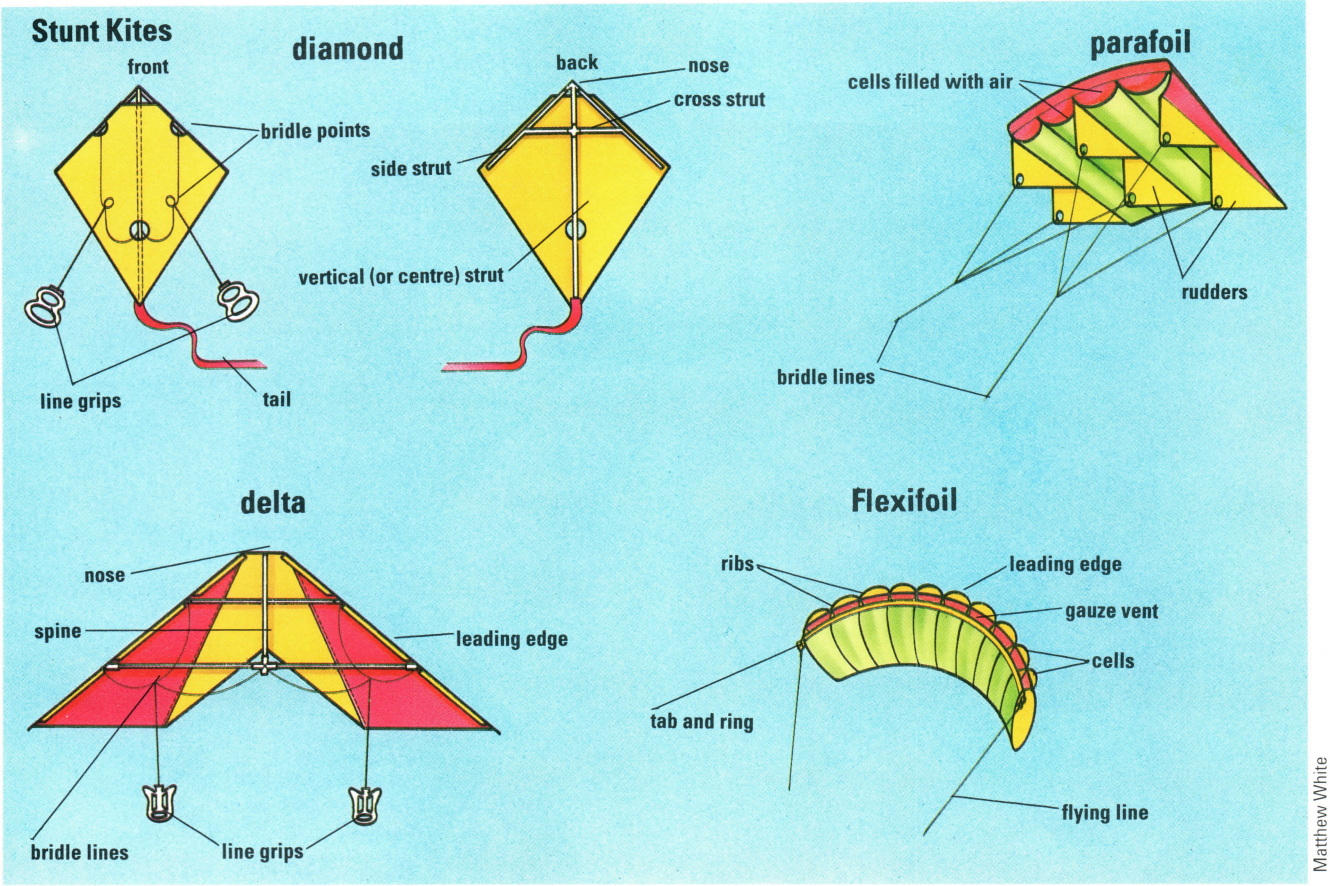
Thermals *– warm rising air – keep a glider airborne. Warm air rises above buildings and ploughed earth because these surfaces absorb heat from the sun more quickly than water or grassy and wooded areas.*

John Carty

PROFILE WORLD GLIDING RECORDS

	Single-seaters	*Hang gliders*
Longest distance in a straight line	**1460.8 km**	**488.19 km**
Longest distance, out and return	**1646.76 km**	**310.302 km**
Greatest height gain	**12,894 m**	**4343.4 m**
Highest altitude reached	**14,938 m**	
Fastest speed	**195.3 km per hour**	





Matthew White

glider up again. For climbing in thermals the wings need to be long, giving a low rate of sink, but for gliding between thermals shorter wings that allow high-speed flight are better. The SB-11 glider overcomes this problem by having wings that can be lengthened by flaps that extend up to 25 per cent in flight.

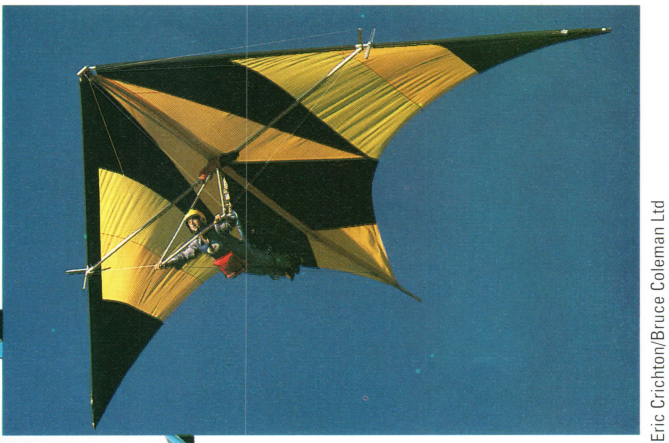
Down to Earth

As it comes in to land, the glider may brake by releasing a small parachute that drags behind it. This enables it to land in a restricted space, such as a small field. Most gliders are also fitted with air brakes. The glider touches down on one wheel located below the cockpit.

Gliders can seat one or two people; two-seaters are often used for training pilots. In the cockpit are a range of flying instruments, including an airspeed indicator, an altimeter and a variometer to show vertical rise and sinking speeds. Additionally, a glider often carries oxygen equipment, a radio and even a computer to track thermals and calculate optimum flying speeds.

'Stunters' have two lines, *giving a kite-flier tight control over them as they climb, dive and swoop in the air. A delta has a similar design to a hang-glider's wing. The cellular pockets on Flexifoils and parafoils provide lift by filling with air in flight.*

High in the sky *the silence is striking, but air currents can make it a bumpy ride. Padded clothing, protects the pilot (below) from freezing cold temperatures at high altitudes.*



Eric Crichton/Bruce Coleman Ltd

Tony Stone Photo Library, London

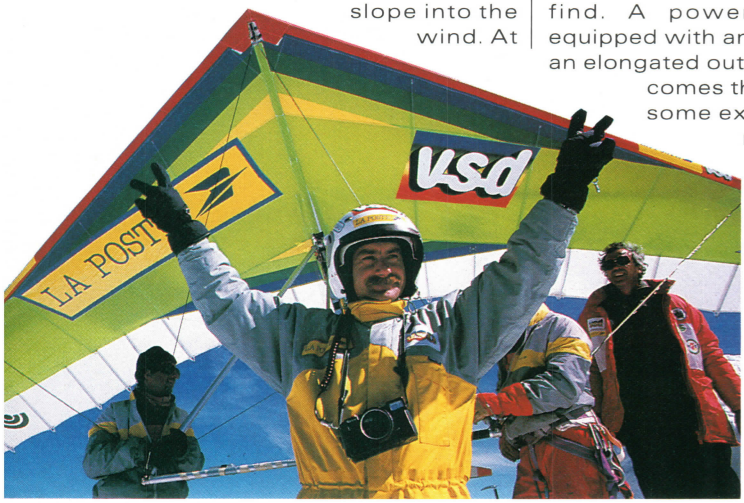
The hang-glider, invented by NASA scientist Dr Francis Rogallo in the 1960s, is built and shaped more like a giant kite than an ordinary plane. The 'wing' is actually a triangular-shaped nylon sail stretched across a light aluminium frame. The pilot is suspended from the frame by a safety harness and steers the craft with a control bar.

A hang-glider pilot takes the glider, folded up, to the top of a hill. It can be folded down in 15 minutes by one

person into a package about 7 metres long with a diameter of roughly 20 cm. The pilot can then fit the glider together and strap him- or herself in ready for flight.

To get airborne, the pilot generally has to run at least 10 metres towards the edge of a steep slope into the wind. At the same time, the craft's nose has to be raised slightly. As the airflow increases, the sail is filled and the hang-glider lifts off the ground. The pilot shifts his weight forward to gain speed by pulling in on the control bar.

To make the hang-glider rise, fall or change direction, the pilot simply shifts his body. Moving his weight back slows the glider down by raising its nose. Leaning forward inclines the pilot's body and the wing closer to the horizontal, thus decreasing resistance to the wind and increasing speed.



Sylvie Chappaz/Allsport

Hang-gliding records

Experienced pilots, taking advantage of powerful updrafts in mountainous regions, travel remarkably high and far. In 1985, American hang-glider pilot Larry Tudor reached a height of 4,343 metres above his take-off spot.

Five years later, he broke the hang-gliding distance record when he covered 488.19 km in a flight from Hobbs Airport, New Mexico, to Elkhart, Kansas.

There are limitations to practising the sport – a strong wind and a suitable hill site are not always easy to find. A powered hang-glider, equipped with an engine the size of an elongated outboard motor, overcomes these restrictions to some extent. As an engine makes the glider less easy to control, some powered hang-gliders also have a wheeled undercarriage for greater stability. Hang-gliders have already been used instead of aircraft in aerial photography and many more roles will be found for them in the future.

Hang-glider pilot *Pascal Morel made a celebratory flight in 1986 to commemorate the 200th anniversary of the first ascent of Mont Blanc in the French Alps.*

The pilot *uses a bar to control a hang-glider. Pushing the bar forwards tilts the craft up at the front and slows it down. Pulling the bar back has exactly the opposite effect.*

F Rickard-Artdia/Allsport

Great escape: *in 1987 Pascal Plante's hang-glider collided with a balloon. Despite falling 800 metres, he survived.*

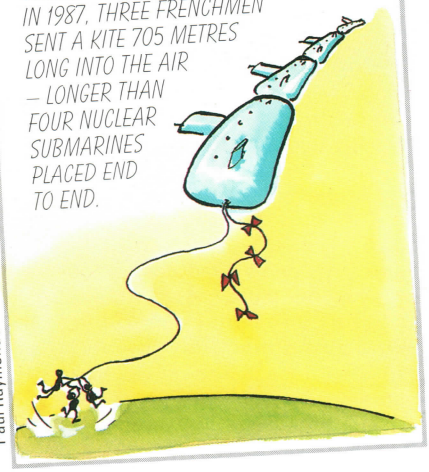
UPWARDLY MOBILE

Insects are sometimes sucked into thermals – in some parts of the world greenfly can be seen rising into the air on hot days. In experiments, fine nets towed behind aircraft caught insects at heights of up to 500 metres.

Just amazing!

CARRIED AWAY

IN 1987, THREE FRENCHMEN SENT A KITE 705 METRES LONG INTO THE AIR – LONGER THAN FOUR NUCLEAR SUBMARINES PLACED END TO END.



Paul Raymonde

Living on a polder – on some of the 40 per cent of reclaimed land in the Netherlands – has distinct advantages.

Ivaldi/Jerrican

- RIVER DELTAS
- BREAKWATERS
- HYDRAULIC DAMS

RECLAIMING THE LAND

World View/Science Photo Library

***The Ijsselmeer** is an enormous lake protected by a great dyke (seen as a thin white line in this satellite photograph). Within the dyke, five polders have been reclaimed. These show as distinctive field patterns with large amounts of blue in them.*

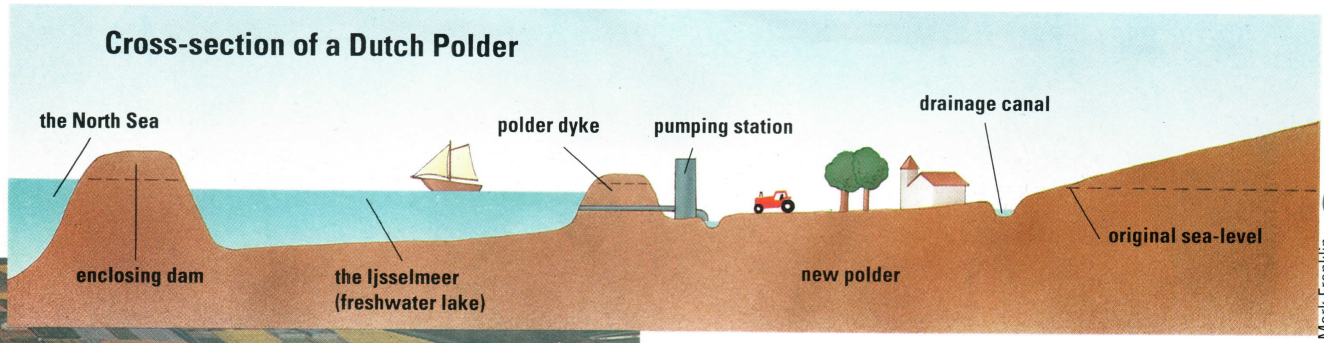
TIDES AND CURRENTS constantly change the Earth's coastlines, eroding in one place, depositing silt and shingle in another. For centuries, Man has attempted to combat the oceans by reclaiming tracts of land.

All over the world coastal marshlands have been drained and turned into rich agricultural land. Where the tide is especially high, or powerful storms are frequent, sea walls are erected to protect the coastline from erosion.

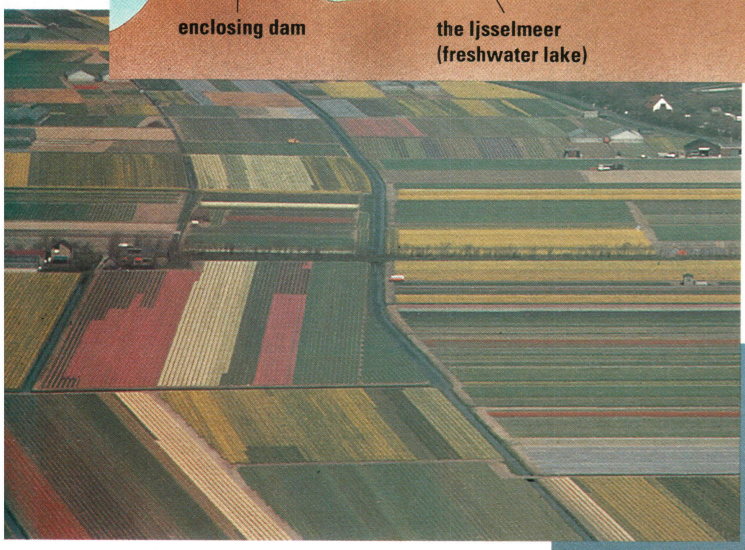
The Dutch, through necessity, are the most experienced reclaimers of land in the world. Much of their country is flat and low-lying. It is also overcrowded. Over 15 million people inhabit an area of just 33,935 sq km – less than one-sixth the size of the UK. In the Netherlands, roughly 40 per cent of the country would be flooded at high tide if it were not for huge artificial barriers.

Polders

As early as the 12th century, the Dutch people began reclaiming stretches of land (called polders) from below sea-level. These early efforts involved building earth dykes and draining off seawater with windmill pumps and a network of ditches. Modern projects are much more advanced, and today 1,300 km of dykes and dams prevent the North Sea from washing twice daily

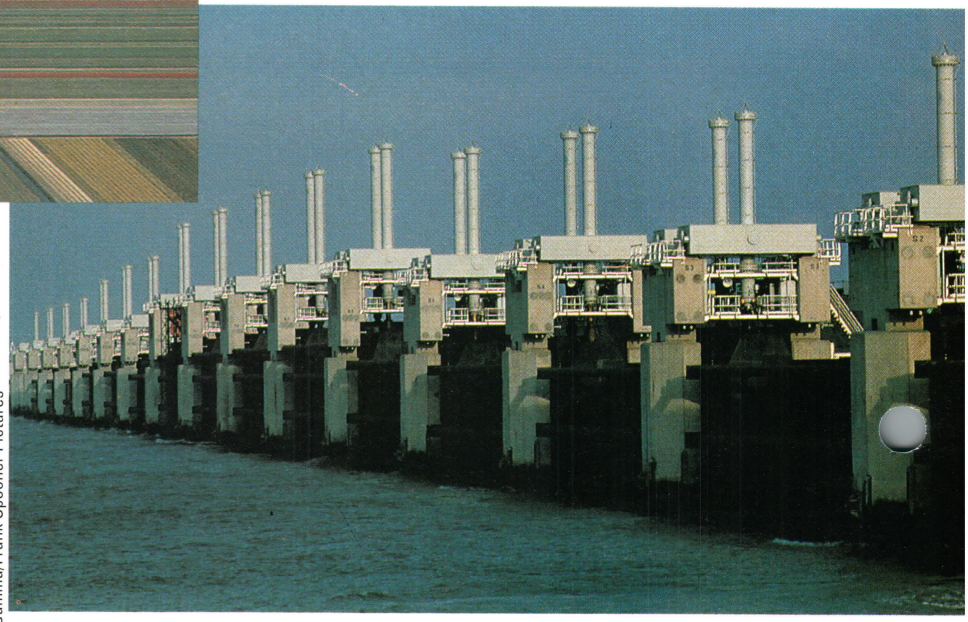


Mark Franklin



***A land area** of 2250 sq km –over twice the area of Hong Kong –has been reclaimed from the original Zuiderzee bay in Holland.*

***The enclosing dam** is built first to separate the sea from the freshwater lake that builds up behind it. A dyke is then built and water is pumped from its land side into the lake. Drainage canals help the new polder to dry out in about five years.*



***The Eastern Scheldt barrier** has 62 gates that remain open except when flooding threatens. This serves to protect the wildlife of the Ijsselmeer that depends on tidal movements.*

Gamma/Frank Spooner Pictures

over this densely populated nation.

In the north of the country, a large shallow bay called the Zuiderzee proved to be the biggest challenge. The world's longest sea dam, the Afsluitdijk (or Great Dyke), was built across the mouth of this bay. Completed in 1932, the dam spans a total of 32.5 km. It has a width at sea-level of 89 metres and is 7.5 metres high measured from the sea bed.

Keeping land dry

Behind the Great Dyke, the salt water has been drained and replaced by a shallow freshwater lake, the Ijsselmeer, fed by inflowing rivers. In the past few decades, five large polders within the Ijsselmeer have been reclaimed. This has been done by constructing dykes around the reclamation sites, then building drainage systems to keep the polders dry. Pumping stations work continuously, drawing water from the surface soil and channelling it away through canals. The largest of the five polders, the Markerwaard, covers 603 sq km, while the total reclaimed land area in the old Zuiderzee bay amounts to 2,250 sq km. Plans to add a further polder to the Ijselmeer have been opposed because wildlife will be disrupted by further reclamation.

Netherlands Board of Tourism

The Delta Plan

The Afsluitdijk withstood one particularly devastating storm in 1953, but south, in Zeeland, at the delta area formed by the Rhine, Scheldt and Maas rivers, 1800 people were drowned and much land was flooded. To prevent such a tragedy happening again the Dutch came up with the 'Delta Plan'. This ambitious project, completed in 1986, linked the islands of Zeeland to the Dutch mainland.

***This honeycombed sea wall,** on the Lincolnshire coast in the UK, helps guard against erosion and flooding. A rock-filled embankment is armoured with large, interlocking, hexagonal, concrete blocks called 'seabees'. This structure absorbs more of the force of the crashing waves of the North Sea than a solid wall.*

National Rivers Authority

Wildlife considerations

The barriers were constructed in increasing order of size so that the experience gained on the smaller ones would help the engineers with the larger barriers.

As work progressed plans were revised, in order to take account of environmental considerations. The

Eastern Scheldt comprises 45 sq km of vegetated mudflat, 26 sq km of shallow water and 24 sq km of deep water. The area teems with wildlife and provides one of Western Europe's major wintering grounds for waterfowl. Lobster, oyster and mussels are bred there and many species of shrimp and fish use the waters as a nursery ground.

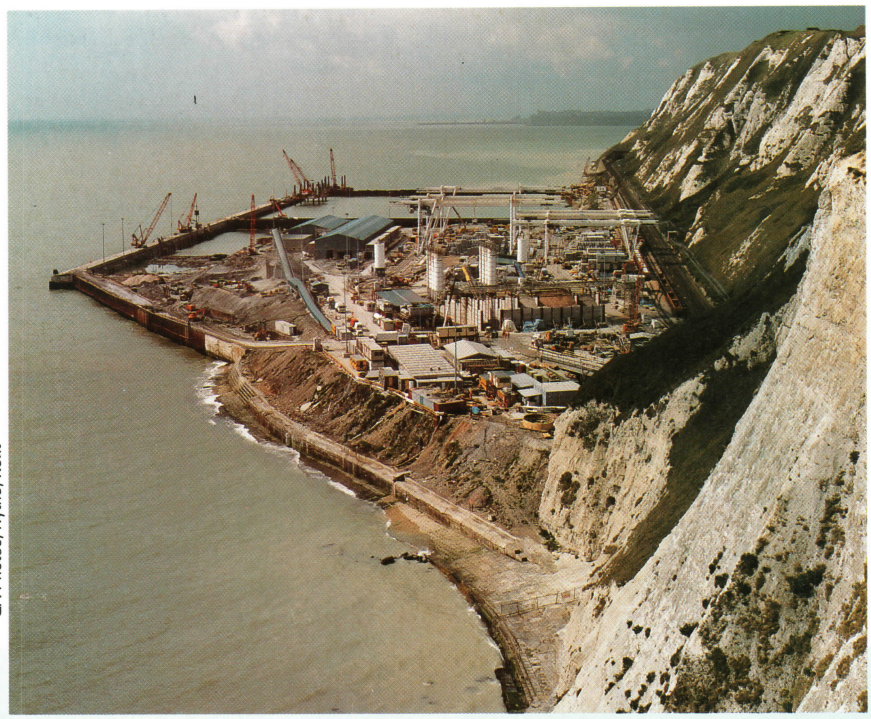
Previous artificial efforts to protect the shoreline have had the side-effect of creating clear waters. This and the relatively high local temperatures have combined to encourage the proliferation of species of marine life normally found much further south.

Rather than sealing off the Eastern Scheldt with a solid dam, a storm-surge barrier with huge steel gates was built. The gates are operated by hydraulic rams and can be closed when storms are forecast, and left open at other times to preserve the natural ebb and flow of the tides. This, the largest dam of the Delta Project, was completed in 1986.

Compacting the bottom

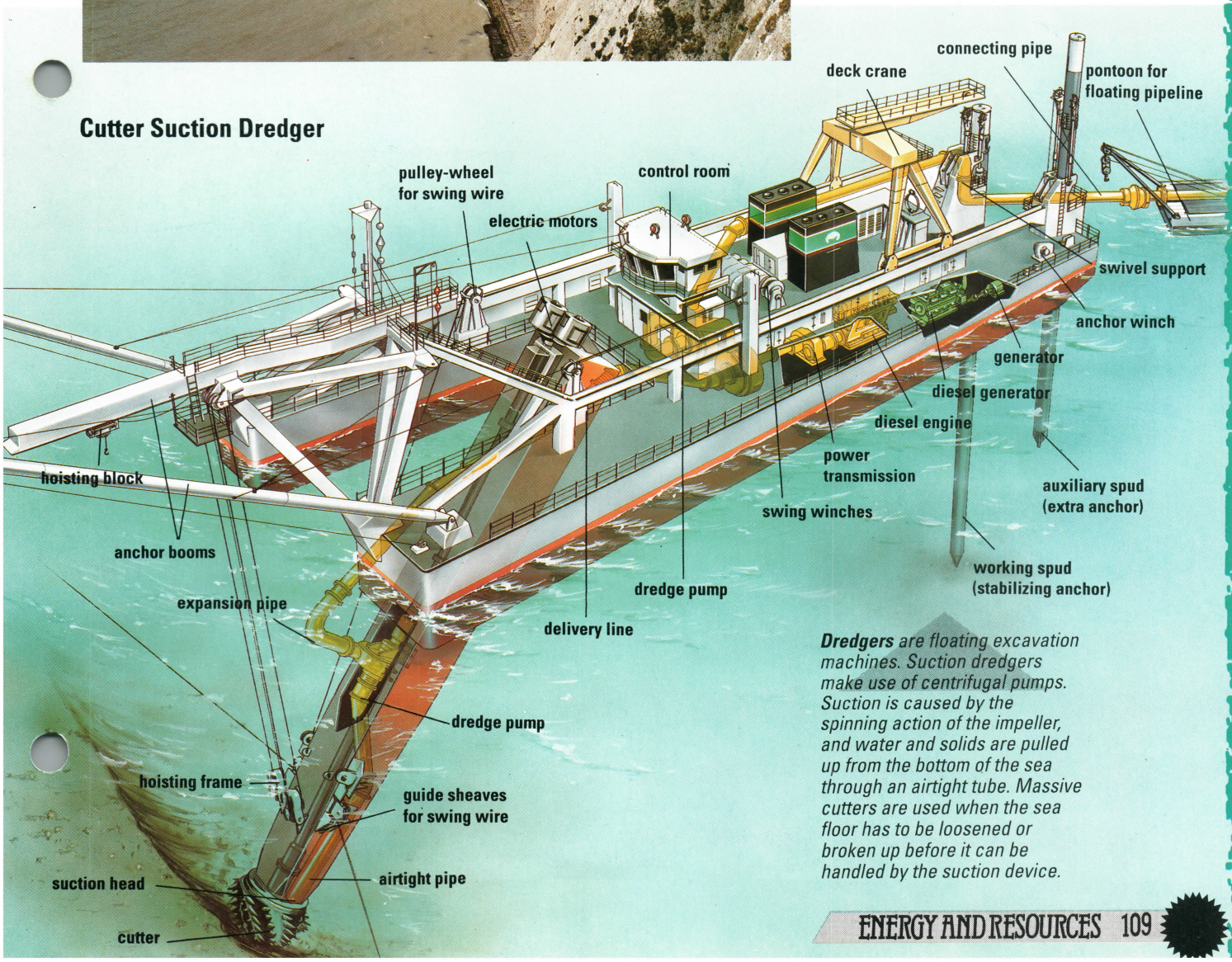
Revolutionary engineering and an extraordinary fleet of construction ships were used for this project. To prepare for the enormous weight of the structure, the sandy bottom of the Eastern Scheldt had to be compacted. This was to prevent strong tidal currents in the area washing away the sand from the base of the dam. Compacting 25,000 sq metres of sea bed, 20 metres below the surface of the sea where strong tidal currents flow over highly porous sands (with an uncertain load-bearing capacity) was a formidable task.

A vessel was specially designed to do this job. The *Mytilus* was



QA Photos, Hythe, Kent

Excavation spoil *from the English end of the Channel Tunnel was used to build a platform under the White Cliffs of Dover. The land will be used for recreation.*



Dredgers *are floating excavation machines. Suction dredgers make use of centrifugal pumps. Suction is caused by the spinning action of the impeller, and water and solids are pulled up from the bottom of the sea through an airtight tube. Massive cutters are used when the sea floor has to be loosened or broken up before it can be handled by the suction device.*

equipped with giant vibration needles each capable of delivering an impact force of about 120 tonnes to the seabed. Such devices are very efficient and lubricate the entry of the needles into the seabed – to depths of 15 metres – by means of jets of air and water. *Mytilus* had a modular construction consisting of five pontoons. The main one was surrounded by four smaller pontoons that could be disconnected when the vessel had to be moved through locks to other work locations.

After the soil was prepared, millions of square metres of sand and gravel matresses were laid down to protect the seabed from erosion. Layers of stony material, also compacted, formed a base for the barrier piers.

Sea defences

A third vessel lowered the 18,000-tonne supporting piers of the dam into place. Each pier stands 40 metres tall – about the same height as a 13-story building. In total they contain enough concrete and steel to build a town to accomodate about 30,000 people. The rest of the structure was assembled using one of the world's largest floating cranes.

Battering against parts of the coast where rocks are soft, the sea can rapidly eat away land, destroying property and valuable farmland. To fight back, engineers have come up with a variety of designs for sea walls and defences:

- vertical walls are the simplest to build, but not the most effective.
- curved sea walls throw the waves up and back on themselves but increase beach erosion so that the wall is undermined and may eventually collapse
- new designs, which aim to absorb the energy of waves and so weaken their destructive force are the most successful. A honeycomb-shaped sea wall at Felixstowe in the UK, for instance, absorbs roughly half of the waves energy and is expected to last for at least 50 years
- a dynamic breakwater designed in the USA is even more advanced. It consists of an array of floats tethered just below the surface of the water that drastically reduces the energy of the waves on impact, before they reach the shore.

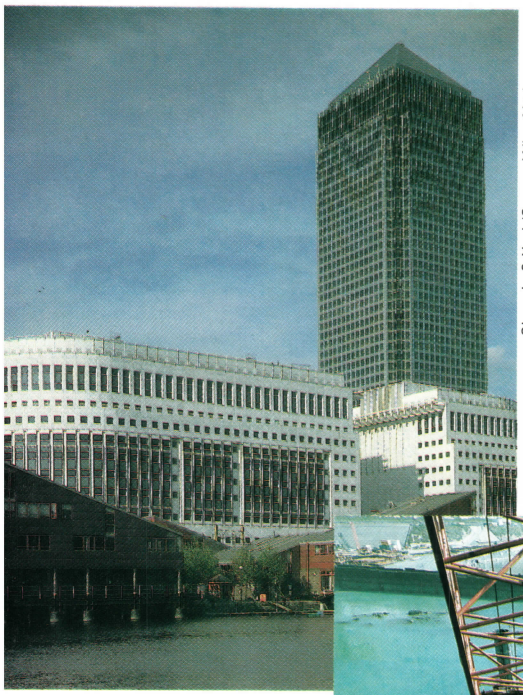
Salt marshes

Low-lying coastal plains are the chief battlegrounds between the sea and the land. In eastern parts of the UK, salt marshes, constantly invaded by the sea, were reclaimed for use as agricultural land long ago. Drainage ditches allowed the salt water to be drained off, while protective embankments, like the great shingle ridge of Dungeness around Romney Marsh in Kent, stand guard against further incursions by the sea. Finally, to make the reclaimed soil fertile it has to be flushed, several times if necessary, by flooding the land with fresh water to reduce its salinity.

In delta areas such as the Rhone in France, and the Mississippi in the Gulf of Mexico, new land is continually being formed by deposition.

Deposition

Silt eroded from further upstream is carried to the delta of the river. There it falls to the river bed as the water speed drops. Here the problems of reclamation can be especially difficult because, through time, rivers may change their courses quite unpredictably. When this happens, the loose, soupy marsh of the abandoned delta, cut off from the river's fresh water and silt, may simply sink under its own weight.



Olympia & York/Canary Wharf Ltd

***Canary Wharf** in London's Docklands is part of a massive development that has transformed the derelict waterfront.*

QA Photos, Hythe, Kent

***The Eurotunnel reclamation project** makes use of jack-ups (movable platforms) from which cranes and other equipment can work. The jack-ups have legs that can be adjusted to keep pace with the sea wall as it grows higher.*

FROM THE ASHES

London Docklands Development Corporation

Land need not necessarily be 'reclaimed' from the sea. This artificial ski slope at Beckton Alps is part of London Dockland's development programme. It is built on a former slag heap and is an example of wasteland being put to good use.

Just amazing!

BEACH BLAST

EVERY DAY, OCEAN WAVES POUND THE WORLD'S SHORES WITH AS MUCH ENERGY AS A 50-MEGATON NUCLEAR BOMB.

Paul Raymonde

PROGRAMMING DEBUGGING HACKING

SOFTWARE DESIGN

COMPUTERS ARE ONLY DUMB machines by themselves. But fed with programs of specially coded instructions they can solve an incredible range of problems at great speed. The brains behind the programs are the programmers — or software engineers as they are known.

These programs, known as software, exist in a number of different forms. For example, an operating system is vital to start up the computer. Applications software, on the other hand, consists of those programs that tell the computer how to solve a particular problem. This may range from playing a simple arcade game to calculating the path of a spacecraft to Mars.

Applications are usually written in a 'high-level' computer language, such as BASIC, which stands for Beginners' All-purpose Symbolic Instruction Code.

Another piece of software called a compiler or interpreter then translates the commands of this language from English into 'machine-level' instructions that the computer's hardware can understand.

Creating Programs

Programming, or software engineering, involves several key stages. First, the problem to be solved by the computer has to be very clearly defined. The programmer has to decide on the exact form the input data and the output data (or results) will take. Then the main processing steps, or logical units, are specified in a flow chart. Finally, the programmer turns

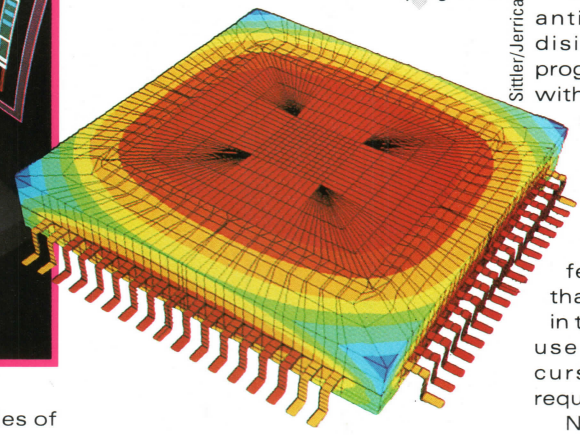
Tony Stone Photo Library, London

The personal computer *can make rapid and complicated calculations, but it would be useless without the right software to drive it.*

Hank Morgan/SPL

Designing a chip, *or integrated circuit, using a light pen. Software engineers are always striving to make computers easier to use.*

Computer graphics *can be generated in three dimensions and in full colour using the latest graphic-design programs.*



Sittler/Jerrican

each flow chart step into a series of instructions in computer language.

The computer user will usually buy a disc or tape containing an application that suits his own needs, such as word-processing, accounting or graphics. But if there is no ready-made package that fits the bill, the user can attempt to develop his own software. This involves either writing his own programs, which can be complicated and time-consuming, or calling in a specialist software developer, who will tailor a program to the user's requirements.

Bugging problems

Software developers are often used by those businesses that need to keep a large database with a list of clients or customers. Specialized software can allow them to link different types of file, such as addresses, and invoices together with data on stock control.

With any type of program, the software engineer's job does not finish when it is written. Because computers are so sensitive, and can contain huge amounts of information, much of a programmer's time is taken up with developing fail-safe devices.

Even the slightest mistake or 'bug', such as a missing comma, is enough to make a whole program fail. For this reason, debugging is a vital part of software development. In some cases, undetected errors can have catastrophic results. On 3 June 1980, for instance, three separate bugs in the USA's computerized early warning system signalled that a Soviet nuclear attack was under way. Fortunately, the problems were spotted in time to avert a full-scale, nuclear counter-strike.

Trojan horses

Another major challenge facing software engineers is how to overcome deliberate computer vandalism, or hacking as it is sometimes known. Harmful programs known as viruses, worms or trojans may be planted in computer systems to cause mischief or damage. These may lie undetected for weeks before being triggered off (see PLANET EARTH pages 91-92).

There are now a large number of anti-virus programs, called disinfectants or vaccines, and programmers are seeking to keep up with new viruses, and even get one step ahead.

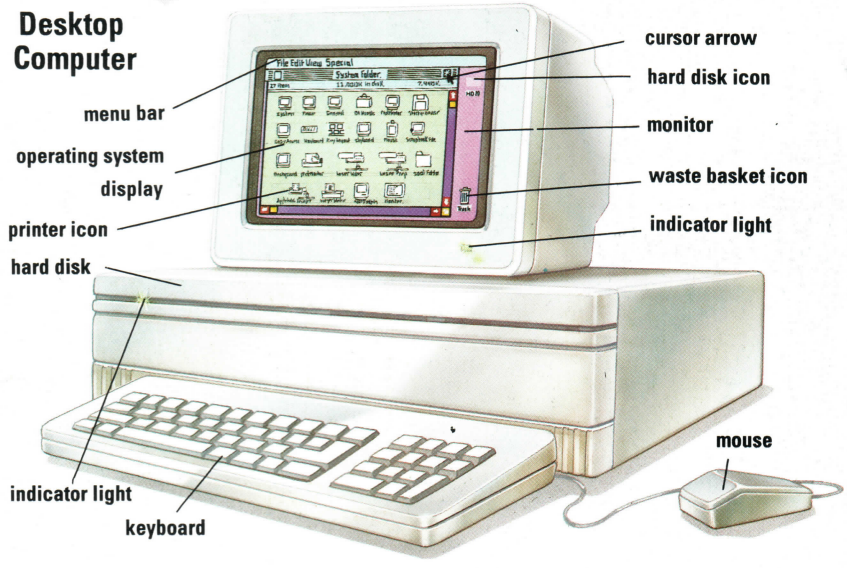
Another major task facing software engineers today is how to make computers simpler for everyone to use. Operating systems increasingly feature a user-friendly interface that sets out the options available in the form of pictures, or icons. The user simply positions a flashing cursor on the screen over the required function.

New developments include 'earcons' that provide audible as well as visual cues to the user. Already some computers can be voice activated using a special headset, and screens that can now be operated at the touch of a finger.

Apple Macintosh and PC 'windows' computers *employ a system of icons on the monitor screen to make them more user-friendly.*

COMPUTER TIME-BOMB

In December 1989, between 10,000 and 20,000 copies of a program purporting to offer advice on the disease AIDS were mailed to owners of IBM personal computers across the UK. Hidden inside the program was a 'trojan' – a piece of software intended to destroy data and other files held on disc. The program's distributor threatened to withhold instructions on how to stop the trojan from doing its dastardly work unless users sent between $180 and $370 to a mysterious address in Panama. The plot was foiled with minimal damage done when a public warning was put out, and eventually an American medical computer consultant was arrested and charged.

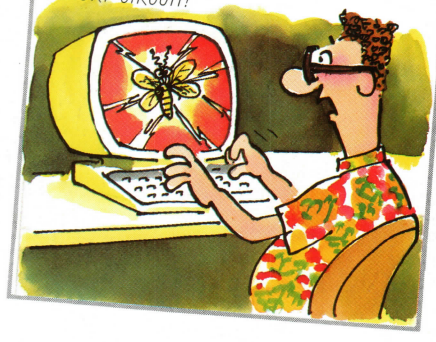


Apple Macintosh/John Houghton

Just amazing!

BUGS IN THE SYSTEM

BUGS WERE NAMED AFTER A REAL INSECT. WHEN AN EARLY COMPUTER GAVE STRANGE RESULTS, ENGINEERS TOOK IT APART AND FOUND THAT A MOTH HAD CAUSED A SHORT-CIRCUIT!



Paul Raymonde